Bilateral flow changes after extracranial-intracranial bypass surgery in a complex setting of multiple brain-feeding arteries occlusion: The role of perfusion studies

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BILATERAL FLOW CHANGES AFTER EXTRA-INTRACRANIAL BYPASS SURGERY IN A COMPLEX SETTING OF MULTIPLE BRAING-FEEDING ARTERIES OCCLUSION: THE ROLE OF PERFUSION STUDIES.

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RUNNING TITLE: Haemodynamic changes after EC-IC bypass

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Abstract

We report on a symptomatic case in which the whole intracranial blood supply was provided by a single vertebral artery as both carotid were occluded and the contralateral vertebral artery was severely hypoplasic. The patient was treated by a flow-augmentation extra-intracranial bypass. Preoperative perfusion studies were essential in tailoring surgical strategy. Keypoint of the paper are contralateral perfusion changes after unilateral bypass surgery. The patient experienced a total recover from symptoms and a bilateral improvement in brain perfusion, probably as consequence of post-operative haemodynamic rearrangement.

Keywords: EC-IC bypass; STA-MCA bypass; DSCE MRI; stroke; bilateral carotid occlusion; cerebral revascularisation;

Introduction

Multiple brain feeding arteries occlusion with complete absence of intracranial carotid supply is rare and is generally associated to uncommon conditions, such as Moya moya disease, fibromuscular dysplasia, arteritis, neurocutaneous disorders, procoagulative disorders, etc [1-2]. When not associated to these features, it represents an uncommon finding, whose management is still challenging[1, 3-5].

Case report

A 64-year-old male smoker affected by hypertension and hypercholesterolemia was admitted for an acute ischemic stroke with mild left-sided hemiparesis. Several transitory ischaemic attacks (TIAs), consisting of left-sided paresthesias, occurred in the last two years, despite antiplatelet medication. No hematological abnormalities were documented.

Brain CT-scan revealed frontal white matter hypodensities that involved both hemispheres. Magnetic resonance Imaging (MRI) demonstrated findings of bilateral watershed infarct, and diffusion weighted images (DWI) clearly depicted bilateral internal border zone acute infarcts (**fig. 1A, B)**.

Magnetic Resonance angiography (MRA) and digital subtraction angiography (DSA) displayed a complete occlusion of both internal carotid arteries (ICA), along with severe hypoplasia of left vertebral artery (VA) **(fig.1C,D and fig.2A,B,C)**. The right VA alone basically provided flow to both the hemispheres through the posterior communicating arteries (PComA) (**fig. 1 C,D, fig.2 D,E**). Spontaneous extra-intracranial (EC-IC) revascularization via the right ophthalmic artery was evident, along with other external anastomoses **(fig. 2F).**

Dynamic susceptibility contrast-enhanced MR imaging (DSCE-MRI) and mean transit times (MTT) maps demonstrated reduced CBF and increased MTT in the right hemisphere, indicating reduced perfusion (**fig.1E**).

On these basis, a right flow-augmentation superficial temporal artery to middle cerebral artery (STA-MCA) bypass was performed using the parietal branch of the right STA.

Postoperative DSA showed the bypass was patent and augmented the blood flow in the operated MCA territory (**fig.2 G,H).**

Postoperative DSCE-MRI showed increase of CBF and reduction of MTT in the right hemisphere compared to pre-surgery: in addition, a tangible improvement on the non-operated side, with a global increase in CBF and reduction of MTT was evident, especially in the temporal lobe **(fig.1F)**..

At three year follow-up, the patient fully recovered from hemiparesis, did not experience any further ischemic episode, neuroradiological studies (perfusion MRI) confirmed the previous findings.

Discussion

The treatment of patients suffering from steno-occlusive disease of the brain feeding extracranial and intracranial vessels is complex [2-4]. Sometime an extracranial-intracranial bypass might be indicated in symptomatic patients, despite antiplatelet administration, presenting with reduced brain perfusion and haemodynamic impairment, in order to prevent clinical deterioration [1, 4].

In the case herein reported the intracranial blood flow was provided by a single VA; DSCE-MRI showed impaired perfusion (low CBF and increased MTT) in the right hemisphere, while changes in CBF and MTT of the left hemisphere were subtle. The patient was then considered at high risk both of chronic hypoperfusion syndrome and of possible future ischemic symptoms, therefore a flow-augmentation bypass surgery was performed. In such cases, angiograms provide for sure important data about the severity of the disease, but the assessment of cerebral perfusion (DSCE-MRI) is crucial in order to establish the hemisphere to be treated, together with patient's presenting symptoms. After unilateral bypass surgery, our patient experienced a total recover from symptoms and a bilateral improvement in brain perfusion, probably as consequence of post-operative haemodynamic rearrangement. In this case no stress test study was performed.

Contralateral perfusion changes after unilateral bypass surgery is a topic so far little analyzed but of particular interest given the complex cerebral hemodynamics resulting from multiple brain feeding

arteries occlusion. Few reports have been reported regarding post-op perfusion and hemodynamic changes of patients affected by Moyamoya vasculopathy[6-8].

In the presented case, before surgery the contralateral (non-operated) hemisphere may have provided collateral flow to the more compromised (operated, and clinically symptomatic) hemisphere. After augmentation of blood flow in the more compromised (operated) hemisphere by means of bypass surgery, this collateral support might become obsolete and an improvement of perfusion in the nonoperated hemisphere could then be expected. The possibility of reversal (from operated to non-operated) collateralization could also be considered[6-8].

In conclusion, more blood flow to the brain could actually have a beneficial effect on bilateral perfusion/hemodynamics. At the moment the patient does not need a controlateral surgical procedure, although we cannot predict the future behavior of brain perfusion and haemodynamics. A close clinical/radiological monitoring is mandatory and further revascularization procedures should be considered in case of worsening of symptoms.

REFERENCES:

1. Albanese A, Esposito G, Puca A, et al. Positional brain ischemia with MCA occlusion successfully treated with extra-intracranial bypass. *Cerebrovasc Dis.* 2010;29(4):408-409.

2. Nakamura K, Yanaka K, Ihara S, Nose T. Multiple intracranial arterial stenoses around the circle of Willis in association with Graves' disease: report of two cases. *Neurosurgery.* Nov 2003;53(5):1210-1214; discussion 1214-1215.

3. Lai SL, Chen YC, Weng HH, Chen ST, Hsu SP, Lee TH. Bilateral common carotid artery occlusion--a case report and literature review. *J Neurol Sci.* Nov 15 2005;238(1-2):101-104.

4. Komotar RJ, Starke RM, Otten ML, et al. The role of indirect extracranial-intracranial bypass in the treatment of symptomatic intracranial atheroocclusive disease. *J Neurosurg.* May 2009;110(5):896-904.

5. Schneider UC, von Weitzel-Mudersbach P, Hoffmann KT, Vajkoczy P. Extracranial posterior communicating artery bypass for revascularization of patients with common carotid artery occlusion. *Neurosurgery.* Dec 2010;67(6):1783-1789; discussion 1789.

6. Esposito G, Fierstra J, Kronenburg A, Regli L. A comment on "Contralateral cerebral hemodynamic changes after unilateral direct revascularization in patients with moyamoya disease". *Neurosurg Rev.* Jan 2012;35(1):141-143; author reply 143.

7. Fierstra J, Maclean DB, Fisher JA, et al. Surgical revascularization reverses cerebral cortical thinning in patients with severe cerebrovascular steno-occlusive disease. *Stroke.* Jun 2011;42(6):1631-1637.

8. Bacigaluppi S, Dehdashti AR, Agid R, Krings T, Tymianski M, Mikulis DJ. The contribution of imaging in diagnosis, preoperative assessment, and follow-up of moyamoya disease: a review. *Neurosurg Focus.* Apr 2009;26(4):E3.

Figure legend

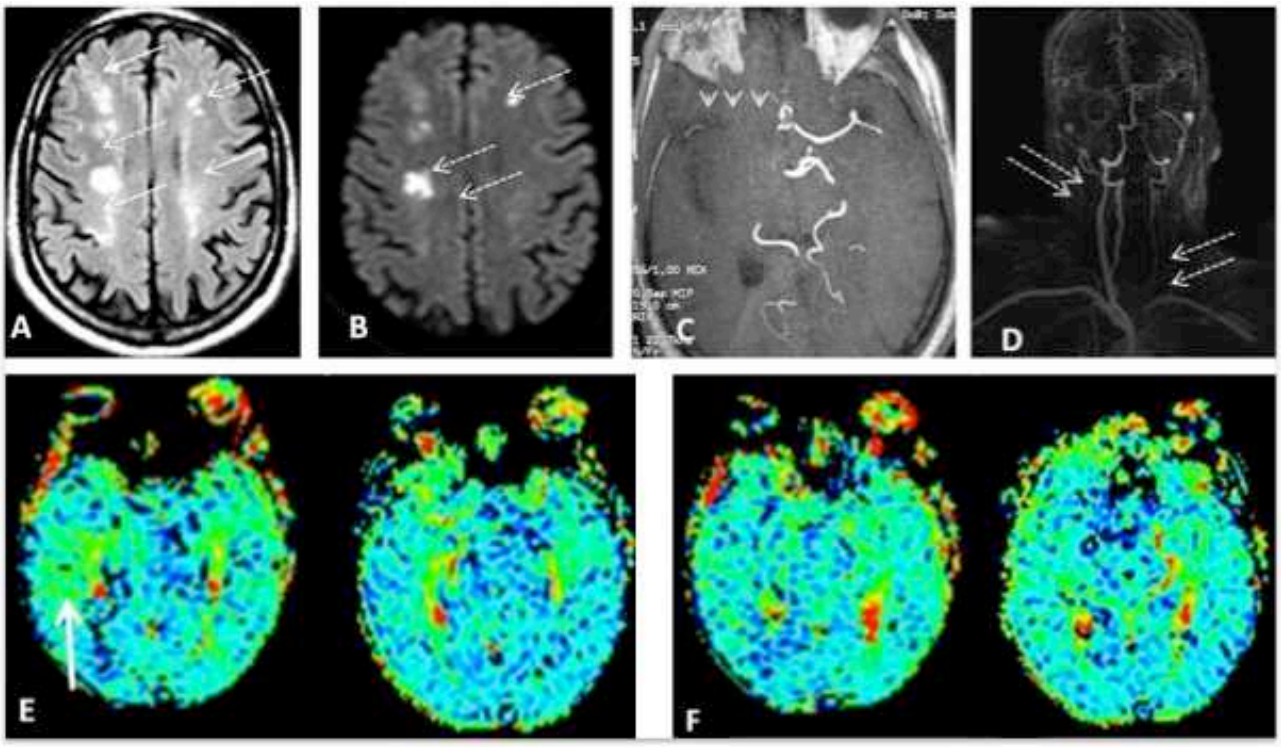

Figure 1:

MRI axial FLAIR image **(A)** showed diffuse areas of leukoencephalopathy (*arrows*), and between them DWI **(B)** depicted bilateral areas of hyperintensity (*dotted arrows*), due to acute ischemic lesions. MR-Angiography of the brain **(C)** demonstrated occlusion of right medial cerebral artery (*arrowheads*), and neck MR-Angiography **(D)** revealed occlusion of right internal carotid artery (*arrows*) and of the left common carotid artery (*arrows*).

MTT maps of DSA-MRI **(E)** showing bitemporal incrase of MTT, right (arrow) > left. Postoperative MTT maps (**F**), at the same levels, showed decrease of MTT in the two temporal lobes (thus also controlaterally to the operated side).

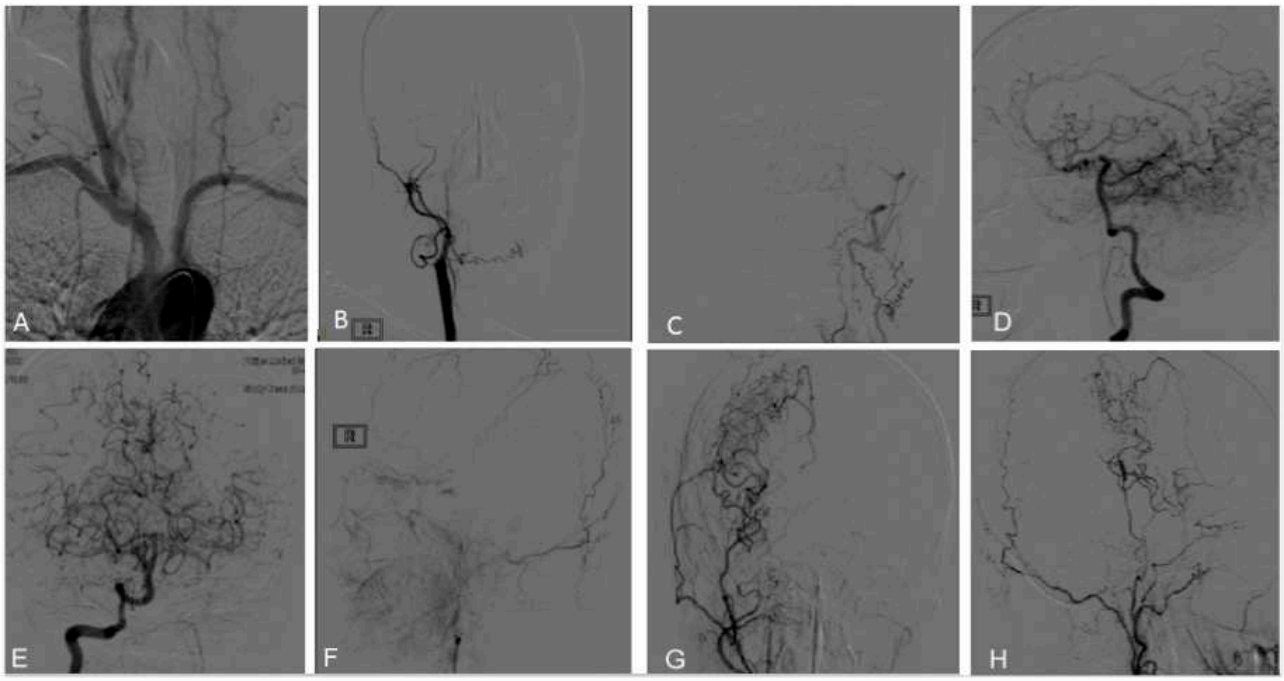

Fig.2 Digital subtraction angiography (DSA) shows occlusion of the left CCA near the aortic arch (A), occlusion of the right ICA at its bulbar origin (B), severe hypoplasia of the left VA (C).
Intracranial blood flow is provided basically by the right VA only through the posterior communicating arteries (PComA) (D,E). Some extra-intracranial revascularization via the right ophthalmic artery was evident, along with other external anastomoses (F). Postoperative DSA documenting bypass patency and flow augmentation in right MCA territory (G,H).